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THE LEVEL OF COORDINATED DEVELOPMENT OF URBAN AND RURAL INFRASTRUCTURE IN GUANGDONG PROVINCE, CHINA

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ABSTRACT

Infrastructure construction influences the coordinated development of urban and rural areas in a significant way. Due to the superiority of urban infrastructure, urban development far exceeds rural development. Recognizing the large gap between urban and rural infrastructure is an urgent concern for China and other developing countries. However, the lack of a comprehensive evaluation system for coordinated development focusing on infrastructure construction is a serious challenge. This paper focuses on Maonan District, Maoming City, Guangdong Province, China, and as a case study, aims to determine the current level on coordinated development of urban and rural infrastructure. Furthermore, it provides suggestions on promotion strategies. In order to achieve the objectives, an optional evaluation list of the contribution of urban and rural infrastructure construction in Maonan District is proposed which is based on a review of relevant literature and indicators for evaluating the contribution of infrastructure projects to coordinated urban-rural development. Based on the optional evaluation list, this study conducted an on-site questionnaire survey at Hongqi Street, as an urban area, and Gaoshan Town as a rural area. A total of 379 samples were collected. SPSS was applied to analyze the data obtained, and indicators for evaluating the contribution of infrastructure projects to coordinated urban-rural development were established. The result of this study determined that there are evident gaps in infrastructure development between urban and rural areas in Maonan District. In spite of urban functions being extended to rural areas, the social benefits of infrastructure in rural areas are much lower than in urban areas. In addition, the benefit of environmental and ecological in urban infrastructure is below the expected standard, highlighting the urgent need for targeted development. It also identified that the current level of urban infrastructure construction has a deep impact on coordinated development. In conclusion, this study improves the evaluation system focusing on the coordinated development of urban and rural infrastructure construction which provides valuable insights for formulating targeted strategies to strengthen the coordinated development of Maonan District and other similar areas.

Keywords:
Urban Infrastructure, Coordinated Development, Construction Evaluation, Constriction Planning, Construction Management

INTRODUCTION

Construction of physical infrastructure facilities refers to the improvement and transformation of construction projects related to infrastructure, which is the common material foundation of all enterprises, units and residents' production, operation, work and life, and the guarantee of the normal operation of main facilities (Gondia et al., 2022). However, increasing urbanization, limited land availability and high costs have resulted in urban areas that can no longer afford horizontal development strategies (Seow et al., 2022). On the other hand, in developing countries, the development of rural areas generally lags behind that of urban areas because the infrastructure in rural areas lags behind that of urban areas. The realization of coordinated development of urban and rural areas has become an urgent issue in China and many other developing countries (Shen et al., 2012).

With the rapid change of human production activities, it is necessary to constantly improve and supplement all aspects of development, the first of which is to develop infrastructure construction (Freelove et al., 2022). Urban and rural areas are different in complexity, foundation and function. To connect urban and rural areas, it is necessary to develop their physical infrastructure in a coordinated manner. It enables urban infrastructure to reach out to rural areas, with urban services also made available to those areas. The application of civil engineering technologies is to improve rural construction's physical infrastructure, hence enhancing agricultural production conditions. At the same time, it should not only consider how the physical infrastructure of the city extends to the countryside but also consider how the original physical infrastructure of the countryside follows up and integrates into the urban areas (Wang et al., 2022). The coordinated development of physical infrastructure construction in urban and rural areas is a process of mutual benefit, common development and joint progress.

However, due to the complexity of functions and the influence of development trends, the level gap between urban and rural infrastructure construction is large, and investigation is difficult. Therefore, most of the critical factors on how different conditions affect the coordinated development of urban and rural infrastructure construction are unknown. The uncertain factors in the construction process are likely to produce serious quality problems in construction (Peng et al., 2023). As a result, due to the scientific nature of this critical factor to achieve the coordinated development of urban and rural infrastructure construction, it is studied more systematically (Shen et al., 2012). Thus, it is necessary to identify the main factors for the uncoordinated development of urban and rural infrastructure construction in order to promote the coordinated development of urban and rural infrastructure in China. It is important to focus on urban infrastructure to explore the level of coordinated development of urban and rural infrastructure construction so as to provide critical indicators for narrowing the development gap.

Infrastructure construction, like other civil engineering construction, needs to be evaluated at the latest implementation level in order to collect valuable data for the construction project to achieve the expected goal, and reduce construction risk due to decision-making mistakes. The objectives of this study are to determine the corresponding development level of urban and rural infrastructure construction, identify the problems and challenges of coordinated development, and improve the evaluation system of coordinated development of urban and rural infrastructure construction. The research area of this study is Maonan District, Maoming City, Guangdong Province, China, and its specific scope is Hongqi Street urban area and Gaoshan Town rural area. First of all, according to the evaluation system of coordinated development of infrastructure projects proposed by Shen et al. (2012), a list of optional evaluation indicators for urban and rural infrastructure construction and development in Maonan District is determined. Then, a questionnaire was made according to the list of indicators to obtain relevant data. The gaps, problems and challenges in infrastructure construction will be combined with more systematic and scientific indicators to assess the contribution of infrastructure construction to the coordinated development of urban and rural areas. Finally, an evaluation system of coordinated development of urban and rural infrastructure construction is established with Maonan District as a case study. The evaluation system is not just an upgrade in the evaluation method of construction projects but also can provide vital strategies for planning and managing the development of urban and rural infrastructure.

LITERATURE REVIEW

Infrastructure construction plays a central role in balancing urban development and ecological civilization, and is a new tool to promote urban and rural coordinated development (Wang et al., 2022). According to researchers of urban balanced development (Wu et al., 2021), the balance of infrastructure is the key driving force for regional development, but the gap between urban and rural areas is still wide, with urban developing too fast and rural developing too slowly.

Infrastructure construction is a system related to power, water, transportation and e-communication, which aims to meet the needs of regional development, ensure the normal operation of the region and provide important services for the region (Gondia et al., 2022). Physical infrastructure is the general term for all kinds of basic material facilities and related products and services that guarantee the normal production and life of a region (Mbuligwe, 2019). The development of infrastructure projects has been an important means to promote the coordinated development of cities in developing countries such as China (Shen et al, 2012).

There are many types of infrastructure in urban areas, classified according to their main purpose, which is to meet the economic, social and environmental development of the urban areas. Urban construction focusses on housing, commercial development, public transport, public services, etc (Wu et al., 2021). More and more aspects of the daily life of people in cities depend to a large extent on large-scale infrastructure systems, including rail, road, water, telecommunications networks, gas and power (Avritzer et al., 2015). Transport infrastructure affects economies and societies, creating favorable conditions for the movement of people and goods. The continuous technological progress has forced the development of transportation and communication infrastructure (Kadyraliev et al., 2022). Urban water systems, which can provide broader social and environmental benefits, mainly in terms of water supply and water treatment, are under increasing pressure due to continued development such as climate change, population growth and urbanization (Nieuwenhuis et al., 2022). At present, in urban development planning, economic and social factors are given priority, and the environment is often the last concern. Although more and more studies are focused on the urban environment, the infrastructure of urban areas is currently composed mainly of transportation, electricity supply, water supply and treatment, and e-communications.

Rural areas usually refer to a geographical area outside of urban areas. China has the largest population of migrant workers in the world. It is a country with deep rural roots, with 56% of the population still living in rural areas (Long et al., 2011; Cheng et al., 2021). This means that the development of rural areas has a huge impact on the whole (e.g. economic, social and environmental). If it is well developed, it will be a great contribution to the balanced development of urban and rural areas. According to previous studies, infrastructure construction plays a dominant role in rural development. Rural areas often lack public transport construction. Transport services are provided less frequently, and private vehicles are often the only option to travel in rural areas (Truden et al., 2022). Implementing infrastructure projects such as roads in rural areas can greatly reduce the production and transportation costs of agriculture and agricultural products, improve the effectiveness and efficiency of economic activity in rural areas, and reduce the impact of natural disasters on farmers. Water conservation, water supply and treatment, sewage and garbage disposal can contribute to coordinated urban ecological development. Electricity and communications in rural areas can boost business and the quality of life in those areas. (Shen et al., 2012). Rural energy refers to energy utilization activities, which are closely related to people in rural areas. Rural energy is an important part of China’s energy structure. Energy consumption in rural areas accounts for a large proportion of China’s energy consumption. Rural energy consumption per capita has exceeded urban energy consumption. Therefore, it is of great significance to study the current situation and development potential of rural energy (Long et al., 2022). According to previous studies, the development of rural infrastructure construction should not only improve the traditional infrastructure construction level of transportation, water supply and treatment, and energy (electricity) supply, but also develop new infrastructure construction of information technology, such as e-communication and internet.

The coordinated development of urban and rural areas refers to the formation of a special relationship between urban and rural areas in spatial distribution, economic investment, ecological environment, social services and other aspects, which means that urban and rural residents may have different lifestyles, but can enjoy similar basic living conditions. If there is a high degree of coordination between urban and rural development, resources can be evenly distributed between urban and rural areas; furthermore, cities will further deprive rural areas of development resources (Tang et al., 2020). Kadyraliev et al. (2022) believe that the better connection between less-developed regions and regions with higher economic and commercial activities has contributed to the easier inflow of production factors, including knowledge, technology, and opportunities to improve the skills of the workforce. The development of rural areas in developing countries generally lags behind that of urban areas because infrastructure in rural areas has not been adequately considered. In other words, to coordinate the development of urban and rural areas, we should take into account the economic, environmental and social development of urban and rural areas as a whole. At the same time, priority should be given to rural areas when formulating regional development plans (Shen et al., 2012). A key aspect of the inherent complexity of infrastructure projects lies in their varying task and technical complexity, as their associated scope of work often requires a high degree of technical knowledge, expertise, and significant multidisciplinary collaborative efforts (Gondia et al., 2022). This means that too much growth in any one piece of infrastructure slows down the rest. Due to the large development demand for urban construction, the development of rural infrastructure is unbalanced. For example, the research results of Wang et al. (2022) have revealed that the urbanization of infrastructure construction has a negative impact on ecosystem services, and the excessive degree of urbanization of infrastructure restricts ecosystem services. Integrating greenery into urban transport infrastructure provides multiple environmental, economic and social benefits. For example, visual contact with a green exterior can improve the mental health and comfort of citizens, especially in densely populated cities where green is lacking (Benoliel et al., 2021). Although the sewage treatment plant has sewage treatment capacity, it does not have the ecological service function. Subsurface flow constructed wetlands, as a treatment process with low cost and high pollutant removal efficiency, are commonly used in the treatment of sewage treatment tail water, and are more common in rural areas than in urban areas (Wu & Golnoosh, 2021).

Indicator System for Assessing the Contribution of Infrastructure Projects to Coordinated Urban and Rural Development

Shen et al. (2012) used mixed research methods to identify a set of indicator systems for assessing the contribution of infrastructure projects to coordinated urban and rural development. The main strategies of this method are:

Firstly, project feasibility reports, relevant literature and official reports of various infrastructure projects were reviewed to filter the indicators currently used to evaluate the contribution of infrastructure projects to coordinated urban development. This finally results in a list of optional indicators (see Table 1).

Secondly, based on this list, a questionnaire was designed in which the data collected were referred to professionals to determine the adequacy and importance of each optional indicator, examining the significance of these indicators in assessing the contribution of infrastructure projects to coordinated urban and rural development.

Table 1: Optional indicators for assessing the contribution of infrastructure projects to coordinated urban-rural development. (Shen et al., 2012)

No.	Optional assessment indicators
1	**Benefit indicators**
1.1	**Economic benefit**
1.1.1	IRR (internal rate of return)
1.1.2	NPV (net present value)
1.1.3	Payback (dynamic)
1.1.4	Loan repayment period
1.1.5	Return on investment
1.1.6	Return on investment before tax
1.1.7	(Direct and indirect) benefit-cost ratio of project
1.2	**Social benefit**
1.2.1	Income level
1.2.2	Living standard and quality (expressed by Engel Indicator)
1.2.3	Employment level
1.2.4	Capability to provide associated facilities (expressed by prevalence percentage)
1.2.5	Capability to provide service (expressed by coverage of service points)
1.2.6	Culture and education level, hygiene and health level
1.2.7	Safety benefit
1.2.8	Amount of benefit compensation of project stakeholders and underprivileged groups
1.2.9	Mutual adaptability indicator
1.2.10	Social risk level (expressed by social risk evaluation value)
1.3	**Environmental and ecological benefit**
1.3.1	Air pollution indicator (degree)
1.3.2	Surface water pollution degree
1.3.3	Solid waste pollution degree
1.3.4	Noise pollution indicator
1.3.5	Landscape impact degree
1.3.6	Water and soil loss impact indicator
1.3.7	Cultural relic and heritage preservation percentage (value)
1.3.8	Energy saving percentage
1.3.9	Recycled use percentage of wastes (or wastewater)
2	**Fairness indicators**
2.1	**Fairness of investment policy**
2.1.1	Preferential treatment of investment policies (for urban or rural areas)
2.1.2	Stability of investment policies
2.1.3	Support degree of investment policies
2.2	**Fairness of investment system**
2.2.1	Fairness of investors
2.2.2	Fairness of investment decision-making
2.2.3	Fairness of financing application reviewing and approval
2.2.4	Investment continuity
2.2.5	Fairness of investment supervision and administration
2.3	**Fairness of investment environment**
2.3.1	Fairness of urban and rural natural resources
2.3.2	Fairness of urban and rural public resources
2.3.3	Fairness of urban and rural energy supply
2.3.4	Fairness of urban and rural economy
2.3.5	Fairness of urban and rural income distribution
2.3.6	Fairness of urban and rural living standard
2.3.7	Fairness of urban and rural market
2.3.8	Fairness of urban and rural technology
2.3.9	Fairness of urban and rural education
2.3.10	Fairness of urban and rural employment
2.3.11	Fairness of urban and rural social security
2.3.12	Fairness of urban and rural law environment

Thirdly, using the collected data, indicators with a supportive response rate of more than 60% were selected as evaluation indicators for further research, the significance level of each indicator was calculated, and the relative significance level of each indicator was derived (see Table 2).

Table 2: Indicators for evaluating the contribution of infrastructure projects to coordinated urban-rural development. (Shen et al., 2012)

Categories of indicators	Indicators	Code
Economic benefit evaluation	IRR (Internal Rate of Return)	X_{11}
	NPV (Net Present Value)	X_{12}
	Payback (dynamic)	X_{13}
	Loan repayment period	X_{14}
	EIRR (Economic Internal Rate of Return)	X_{15}
	ENPV (Economic Net Present Value)	X_{16}
	(Direct and indirect) cost-benefit ratio of projects	X_{17}
Social benefit evaluation	Employment status	X_{21}
	Living standard and quality (expressed by Engel Indicator)	X_{22}
	Capability to provide associated facilities (expressed by prevalence percentage)	X_{23}
	Culture and education level, hygiene and health level	X_{24}
	Safety benefit	X_{25}
	Amount of benefit compensation of project stakeholders and underprivileged groups	X_{26}
	Mutual adaptability	X_{27}
	Social risk level (expressed by social risk evaluation value)	X_{28}
Environmental and ecological benefit evaluation	Air pollution indicator (degree)	X_{31}
	Surface water pollution degree	X_{32}
	Solid waste pollution degree	X_{33}
	Noise pollution indicator	X_{34}
	Water and soil loss impact indicator	X_{35}
	Cultural relic and heritage preservation percentage (value)	X_{36}
	Energy saving percentage	X_{37}
	Recycled use percentage of wastes (or wastewater)	X_{38}
Fairness of investment policy	Preferential treatment of investment policies (for urban or rural areas)	X_{41}
	Stability of investment policies	X_{42}
	Support degree of investment policies	X_{43}
Fairness of investment system	Fairness of investors	X_{51}
	Fairness of investment decision-making	X_{52}
	Fairness of financing application reviewing and approval	X_{53}
	Investment continuity	X_{54}
	Fairness of investment supervision and administration	X_{55}
Fairness of investment environment	Fairness of urban and rural natural resources	X_{61}
	Fairness of urban and rural public resources	X_{62}
	Fairness of urban and rural energy supply	X_{63}
	Fairness of urban and rural economy	X_{64}
	Fairness of urban and rural income distribution	X_{65}
	Fairness of urban and rural living standard	X_{66}
	Fairness of urban and rural technology	X_{67}
	Fairness of urban and rural education	X_{68}
	Fairness of urban and rural employment	X_{69}
	Fairness of urban and rural social security	X_{610}
	Fairness of urban and rural law environment	X_{611}

Finally, a system of critical indicators was established to assess the contribution of infrastructure projects to promote coordinated urban-rural development. The indicator system consists of 19 critical indicators, covering 6 dimensions: economic benefit, social benefit, environmental and ecological benefit, equity of investment policy, equity of investment system and equity of investment environment (see Figure 1).

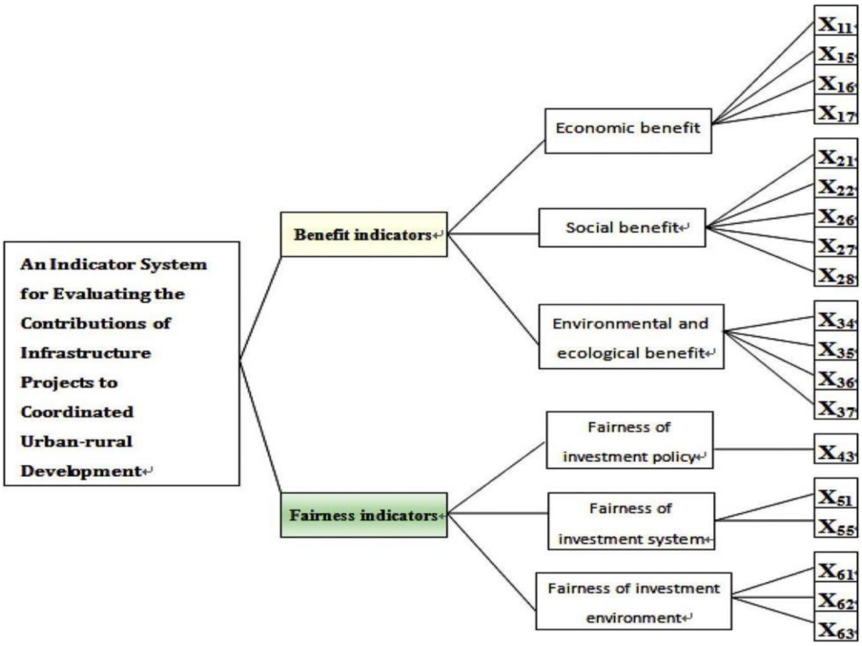


Figure 1: An indicator system for assessing the contribution of infrastructure projects to coordinated urban-rural development. (Shen et al., 2012)

Social Impact Indicators

Transportation infrastructure, as an important part of the social transportation system, has become one of the main items affecting the process of urbanization. Transportation is the core of social development in geographical space. Perfect transportation infrastructure can promote the flow of various production factors and constantly promote the process of urbanization. With the continuous improvement of science and technology, the demand for transportation infrastructure is also increasing. Influenced by the improvement of income level and urbanization level, car ownership keeps rising, and traffic pressure increases accordingly (Kadyraliev et al., 2022; Nikolaev et al., 2022; Arts et al., 2021; Yannis et al., 2022).

Rural transportation infrastructure is a necessary condition to promote the smooth development of rural economy and villagers' production and life. Transportation infrastructure is especially important in rural areas where private transportation is the only option for people to get around, with few public transportation facilities. Without good transportation facilities, rural areas cannot introduce all kinds of equipment and technology, and it is difficult to promote all kinds of development (Long et al., 2011; Ma et al., 2021; Shen et al., 2012; Truden et al., 2022). To sum up, transportation infrastructure plays an important role in the development of urban and rural areas. It could even be said to be the most critical factor.

Environmental & Ecological Impact Indicators

Water is essential in people's daily life. Water supply and treatment are therefore important components of urban and rural infrastructure. In order to guarantee people's living and industrial production, a region must have a perfect sewage treatment system. Water supply facilities are important urban infrastructure, which is an important support for ensuring and improving people's livelihood and promoting the coordinated development of urban and rural areas. Issues such as rainstorm weather, urban water logging, smooth drainage, and water pollution have been the focus of the problem. Of course, rural areas are no exception. (Avritzer et al., 2015; Shen et al., 2012; Nieuwenhuis et al., 2022).

Energy consumption in urban areas is huge and only electricity power can be supplied to a greater extent. Energy demand in rural areas is not as great as in urban areas, but electricity has become a demand in rural areas. Especially with the development trend of electric power technology, electric infrastructure is essential. Electricity power is the main energy source at present. Electricity power is the key point to promote the energy transition and achieve the goal of carbon peak carbon (Avritzer et al., 2015; Long et al., 2022).

With the continuous development of internet technology, it has played a very important role in the development of urban areas. Nowadays, life has been completely inseparable from internet technology. In both urban and most rural areas, daily communication is almost exclusively electronic. More and more energy management uses Internet technologies, such as the use of ICT cards to manage the cost of water, electricity and gas supplies; REI are proposed to monitor and manage rural living, farming and other related energy activities (Avritzer et al., 2015; Long et al., 2022).

As the foundation of human existence and development, land resources are an important source of all production and all existence. The same plot of land will have varied results depending on the edges, time, shape, and other factors. Therefore, land must be developed under a good planning strategy (Tang et al., 2020; Wu et al., 2022; Ma et al., 2021).

Optional Indicators

In this study, the determination of the optional indicators for evaluating the contribution of infrastructure projects to coordinated urban development is based on the summary of previous relevant literature and the analysis of influencing factors. As mentioned above, infrastructure projects have two main influences on coordinated urban development: Social and Environmental & Ecological.

Based on the evaluation model of Shen et al. (2012), the optional indicators for assessing the contribution of infrastructure projects to coordinated urban-rural are listed in Table 3.

Table 3: Optional indicators for assessing the contribution of infrastructure projects to coordinated urban-rural development. (Made by author)

No.	Optional assessment indicators
	Benefit indicators
1	**Social benefit**
1.1	Road
1.2	Bridge
1.3	Highway
1.4	Railway
1.5	Subway
1.6	Bus Station
2	**Environmental and ecological benefit**
2.1	Water supply
2.2	Wastewater treatment
2.3	Internet technology
2.4	Power supply
2.5	Solid waste
2.6	Greenery
2.7	Land planning

RESEARCH METHODOLOGY

Research Design

In reference to previous literature reviews and research, and the indicators system (Shen et al., 2012), the Indicators for Evaluating the Contribution of Infrastructure Projects to Coordinated Urban-Rural Development were determined as per Table 4. Then, based on this list, a questionnaire was designed to determine the adequacy and importance of each optional indicator through the people concerned. Questionnaire surveys are usually open-ended so that in-depth data and information can be collected. It is a social research method in the professional field.

Table 4: Indicators for evaluating the contribution of infrastructure projects to coordinated urban-rural development. (Made by Author)

Categories of indicators	Indicators	Code
Social benefit evaluation	Road	X 11
	Bridge	X 12
	Highway	X 13
	Railway	X 14
	Subway	X 15
	Bus Station	X 16
Environmental and ecological benefit evaluation	Water supply	X 21
	Wastewater treatment	X 22
	Internet technology	X 23
	Power supply	X 24
	Solid waste disposal	X 25
	Greenery	X 26
	Land planning	X 27

This questionnaire is designed according to the indicators system in Table 4 based on Shen et al. (2012) and Benoliel et al. (2021). The questions in the questionnaire survey were designed and structured to match the research objectives to obtain the requirement. The questionnaire is divided into four sections.

- Section A: Demographic Information
- Section B: The Construction Level of Urban Infrastructure
- Section C: Problems and Challenges Existing in the Level of Urban Infrastructure Construction to Promote Coordinated Development
- Section D: The Strategy of Promoting the Coordinated Development of Urban and Rural Infrastructure Construction

Sample Size of Population

In order to reflect the significance of the case study, Hongqi Street in Maonan District is selected as a case study for urban areas, and Gaoshan Town as a case study for rural areas. Hongqi Street which belongs to Maonan District is located in the southwest of Maoming City. It has an area of 6 square kilometers and a population of 8,598. Gaoshan Town, belonging to Maonan District, is located in the southwest of Maoming City. It is the typical suburban junction with an area of 12.19 square kilometers and a population of 18,119. The two areas, with a total population of 26,717, are adjacent and have frequent activities between them, which makes it easier to show the difference between urban and rural infrastructure construction. In this study, an online sample calculator (*https://www.calculator.net/sample-size-calculator.html*) was used to obtain the sample size. Based on the calculation with a confidence level of 95% and an error of5%, the sample size of the survey should be 379. For the principle of data fairness, the sample size of 379 is divided according to the proportion of each region in the total population. A total of 122 respondents were randomly surveyed in Hongqi Street. A random survey of 257 respondents was conducted in Gaoshan Town.

Data Collection & Analysis

In this study, quantitative methods were adopted. Quantitative research emphasizes predictive control, the objective reality of facts, and experiential verification. This will be used in all sections. The quantitative method is also used to summarize the data and information of the whole questionnaire. The type of questionnaire is the on-situ survey method in the form of Statistical Package for Social Sciences (SPSS). It targets both urban and rural residents in Maonan District, Maoming City, Guangdong Province, China. The questionnaire was processed by Word software, and the relevant urban and rural residents were surveyed and recorded through electronic social software. The respondents were asked to answer the questions truthfully. The researcher then analyzed and summarized the information gathered from the questionnaire in order to achieve the aims and objectives related to this study.

RESULTS AND DISCUSSION

Section A: Demographic Information

Table 5 shows a detailed summary of Respondents' Demographic in the urban area and rural area. The results showed that all respondents were working people between the ages of 20 and 60. Most respondents from both urban and rural areas work in urban areas. Respondents in rural areas have lower income and lower education levels compared to those in urban areas. The mobility of residence rates in urban areas is greater than in rural areas. Overall, a disharmony between urban and rural infrastructure construction and development is found, where most respondents believed that conditions in urban areas are better than those of rural areas.

Table 5: Respondents' Demographic in Two Areas

Demographic	**Classification**	**Percentage (%)**	
		Urban Area (Hongqi Street)	**Rural Area (Gaoshan Town)**
Age	10-20	0	0
	20-60	100	100
	>60	0	0
	Mean	2.00	2.00
Work Status	Yes	100	100
	No	0	0
	Mean	1.00	1.00
Possession of Car	Yes	59.02	40.98
	No	58.75	41.25
	Mean	1.44	1.57
Education Level	Primary School	0	0
	Middle School	34.43	43.97
	High School	39.34	33.85

	University	26.23	22.18
	Mean	2.78	2.71
Enough Monthly Income	Yes	72.13	57.95
	No	27.87	42.41
	Mean	1.28	1.57
Work Area	Urban Area	82.79	85.99
	Rural Area	17.21	14.01
	Mean	1.17	1.00
Duration of Residence	Long-term Living	83.61	90.27
	Short-term Living	16.39	9.73
	Mean	1.17	1.00

Section B: The Construction Level of Urban Infrastructure

Table 6 shows the analysis for the current level of infrastructure of both areas. The construction level was ranked based on 1 to 5 (where 1 = very bad; 2 = bad; 3 = medium; 4 = good; and 5 = very good). The power supply (Scale = 4) in urban and rural areas are both rated good, with a mean of 4.17 in urban areas and 4.14 in rural areas. It means that the level of infrastructure construction of power supply is relatively coordinated currently. The worst infrastructure in both regions is land (scale=1), with a mean of 1.83 in urban areas and 1.00 for rural areas. This reflects that there is a large gap in the coordinated development of urban and rural infrastructure construction. By contrast, the level of infrastructure construction in urban areas is obviously higher than that in rural areas.

Table 6: The Construction Level of Urban and Rural Infrastructure

Infrastructure	**Urban Area (Hongqi Street)**		**Rural Area (Gaoshan Town)**	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**
Water Supply	4.00*	0.34	3.14	0.85
Water Treatment	4.00*	0.67	2.00	0.00
Road	4.22*	0.42	3.14	0.36
Bridge	3.28	0.65	2.71	0.46
Internet	4.39*	0.49	3.71	0.71
Power Supply	4.17*	0.38	4.14*	0.36
Disposal of Solid Waste	3.21	0.98	2.29	0.71
Land	1.83	0.38	1.00	0.00

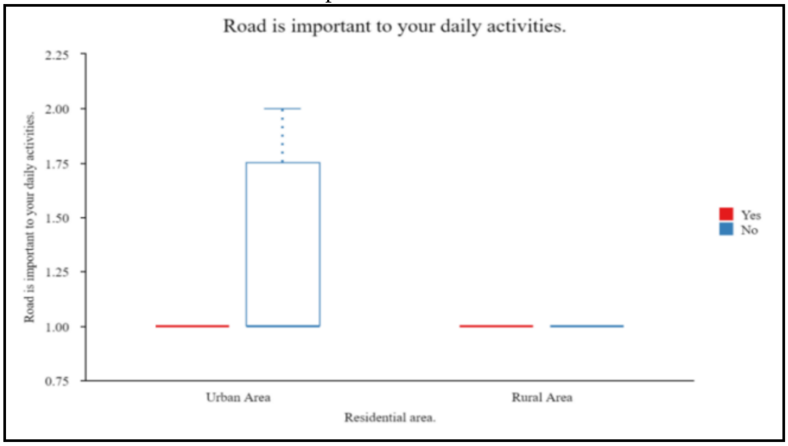
*(*Note: scale of 1–5: 1 = very bad; 2 = bad; 3 = medium; 4 = good; and 5 = very good.)*

Discussion of Finding in Section B: The Level of Infrastructure Construction In Urban Areas Is Much Higher Than That In Rural Areas

According to the final part of Section B of the questionnaire survey, the internal infrastructure construction in most urban areas of China maintains high-quality development, but the development trend is obviously rising, and diversified and complicated. There is a big gap between urban and rural development of infrastructure construction. It shows that the planning and management for the coordinated development of urban and rural infrastructure construction in China is still inadequate, especially the lack of a set of systematic evaluation systems. The study shows that infrastructure construction in most cities currently focuses on the development of urban areas in China.

Section C: Problems and Challenges Existing in the Level of Urban Infrastructure Construction to Promote Coordinated Development

Figure 2 shows whether ownership of a private car impacts the importance of roads to the respondents. Through the boxplot, it can be seen that the construction of road infrastructure has a great impact not only on activities using private cars but also on non-private car activities. Secondly, it reflects that the diverse urban transportation infrastructure makes urban respondents who do not own a car have a great difference in their views on the importance of roads. Therefore, there are many unstable factors in road construction, which brings more challenges to the coordination of urban and rural road infrastructure construction and development.



*(*Note: scale of 1–2: 1 = Important; 2 = Not important.)*

Figure 2: The impact of private cars on the importance of roads

Figure 3 shows the importance of bridges to respondents who own and don't own a private car. Notably, there was a trend of intersection between respondents who thought bridges were very important (53%) and those who thought bridges were not (47%). This suggests that bridges in some areas have little or no impact on private car use. This means that bridges mainly have the greatest impact on travel activities, such as the use of private cars. Besides, with the change in the number of private cars owned by residents, the development of bridge infrastructure construction also has great fluctuations, especially in the aspect of coordinated development between urban and rural areas.

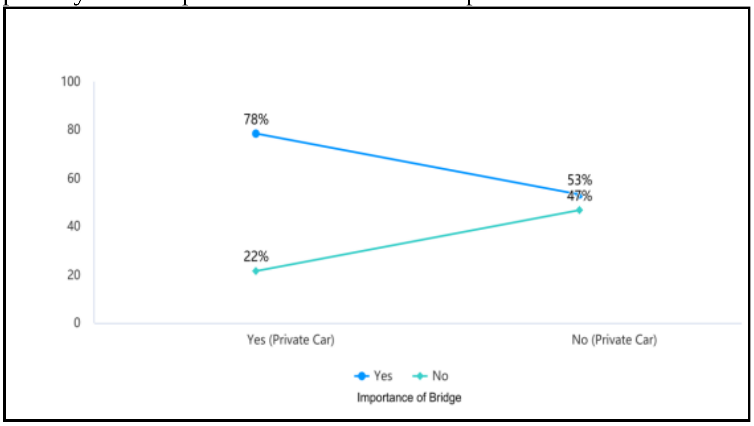


Figure 3: The impact of ownership of private cars on the importance of bridge

Figure 4 shows the importance of internet infrastructure construction to the daily life of urban and rural residents. It can be seen that all urban respondents (100%) think the internet is important, while most rural respondents (89.88%) also think the internet is important. It shows that in the internet times, people's demand for internet infrastructure construction is great. While urban areas are still in urgent need of development, if the coordinated development of urban and rural internet infrastructure has not been given due attention, the gap will be even wider. This is especially so in terms of the top-down characteristics of internet infrastructure construction, with the challenge of coordinated development between urban and rural areas being greater.

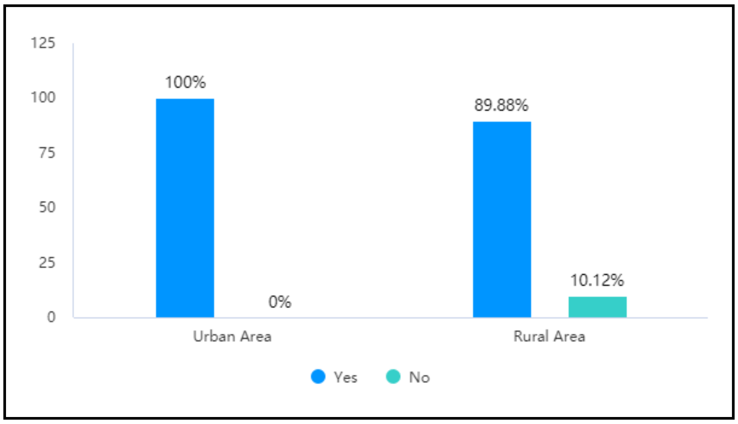
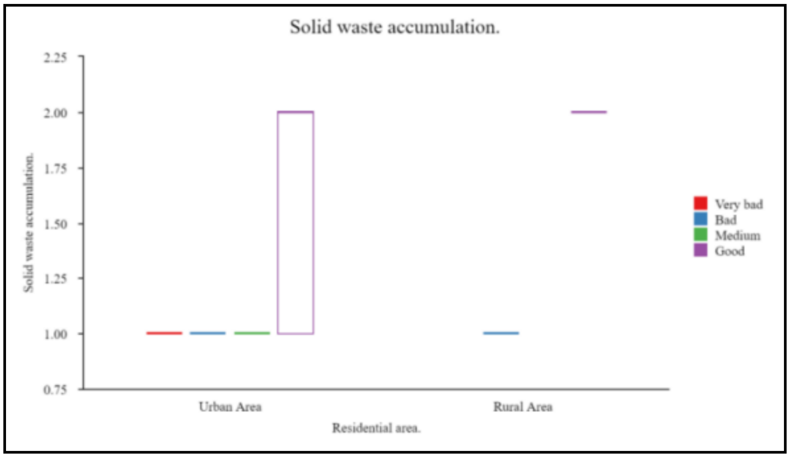


Figure 4: The importance of the internet

Figure 5 shows the solid waste accumulation in different statuses of solid waste disposal in urban and rural areas. It can be seen that the trend of solid waste accumulation near the residence is obviously inconsistent with the status of solid waste disposal. Solid waste accumulation tends to be consistent with the status of solid waste disposal. For example, the solid disposal treatment is better where the solid waste accumulation is less. This means that the development of solid waste treatment infrastructure construction is still low, and more factors need to be considered.



*(*Note: scale of 1–2: 1 = No accumulation; 2 = Accumulation.)*
Figure 5: Solid waste accumulation

Figure 6 shows the effects of water supply status on smooth water supply in urban and rural areas. It can be seen that the construction of water supply infrastructure in the urban areas records medium, good and very good status, and all urban respondents believe that the water supply is smooth. Even in the few places in the urban area where the water supply is very bad, there are still people who believe that the water supply is smooth. Obviously, the water supply in urban areas is at a perfect level, and the challenge for the coordinated development of urban and rural water supply infrastructure is how to develop rural areas without neglecting to maintain the perfect level of water supply in urban areas.

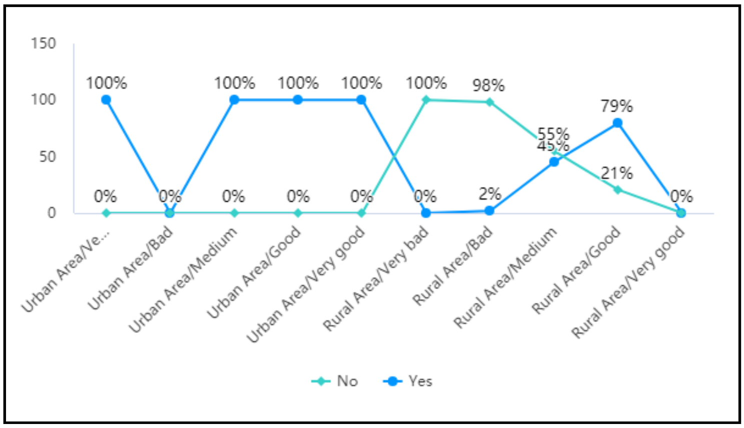


Figure 6: The Effect of Water Supply Status on Smooth Water Supply

Figure 7 shows the effect of wastewater treatment status on sewage discharge satisfaction. The effect trend in urban areas fluctuated little, while that in rural areas increased slowly. This means that the development trend of wastewater treatment infrastructure construction is slow, especially the huge difference, which brings double challenges to the coordinated development of urban and rural areas.

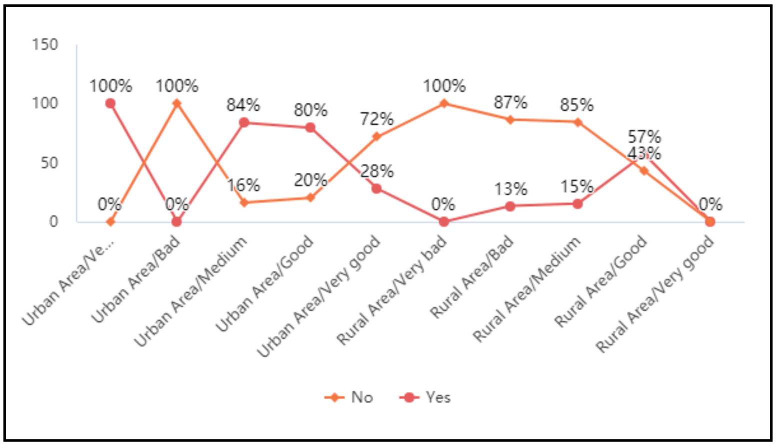


Figure 7: The effect of wastewater treatment status on sewage discharge satisfaction

Figure 8 shows that the effect of power supply status on power supply satisfaction. As can be seen, urban respondents are satisfied that the power supply in urban areas remains in good and very good condition. For the coordinated development of urban and rural power supply infrastructure construction, rural areas with relatively backward development levels and large horizontal spans will face more challenges.

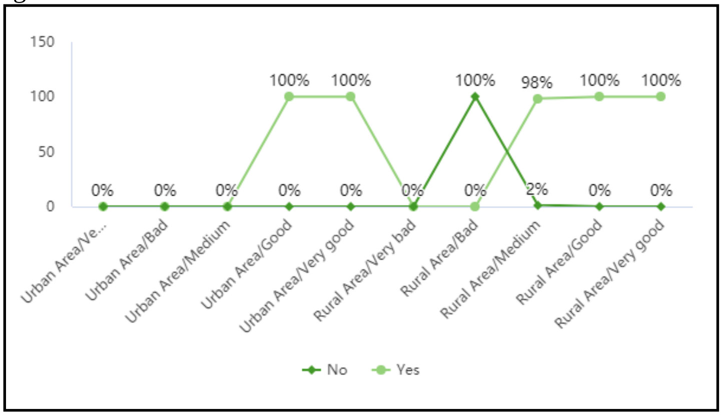


Figure 8: The effect of power supply status on power supply satisfaction

Figure 9 shows the effect of abandoned land on greenery. Obviously, for urban respondents, those who have abandoned land near their area think that the afforestation level is in bad or very bad state. This is contrary to the situation in rural areas, indicating that the situation of abandoned land in urban areas is not the same as that in rural areas. Respondents who think that there is no abandoned land in urban areas think that the greening level is in a bad or medium state, which indicates that the area of abandoned land in urban areas has little influence on greening. It means that urban and rural land development is very uncoordinated, and for urban areas under the premise of complex infrastructure, the reasonable development of green will face a lot of obstacles.

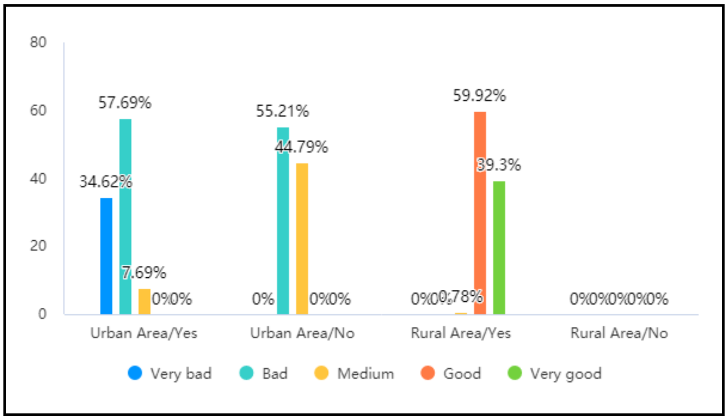


Figure 9: The effect of abandoned land on greenery

Discussion of Finding in Section C: The Lack of a Perfect Evaluation System and The Complexity of Different Individual Conditions on Demand Are the Barriers and Challenges to The Uncoordinated Development of Urban and Rural Infrastructure Construction

From Section C, it can be found that many respondents' satisfaction with infrastructure is greatly affected by their personal circumstances, such as whether the respondents own a vehicle in terms of their views on transportation infrastructure. Therefore, the obstacle to the coordinated development of urban and rural infrastructure construction is the evaluation system. As we all know, the premise of planning and management of construction projects is the survey. Without scientific and high-quality surveying, there is no high-quality planning or design. Management is then difficult. For infrastructure construction, evaluation is very important. It can help engineers collect more information and data in the formulation of urban and rural planning, so as to better understand and analyze the current situation, making decisions more effective. Although there are already perfect evaluation systems and survey methods for engineering construction in China, there is no perfect evaluation system for the topic of coordinated development of urban and rural infrastructure construction. Even though the current infrastructure construction has a systematic life-cycle process of survey-evaluation-design-planning-construction-management in China, evaluation is also a prerequisite to support the correct implementation of infrastructure construction projects. If there is no evaluation system for the coordinated development of urban and rural infrastructure construction, the coordination of urban and rural infrastructure construction cannot be formed.

Section D: The Strategy of Promoting the Coordinated Development of Urban and Rural Infrastructure Construction

Figure 11 shows the priority for infrastructure construction. As can be seen, transportation has the highest percentage (29.29%), followed by water treatment (29.02%), solid waste disposal (15.83%), ecological environmental protection (12.40%), water supply (10.03%), and the Internet (3.43%). Transportation infrastructure is a prerequisite for the development of the rest of the infrastructure construction. Without transportation, it is difficult to carry out respective production activities. So, it makes sense to put transport infrastructure first. Water treatment is preferred over water supply because substandard water treatment will directly affect the quality of water supply. Water is a daily necessity for people. So, it is reasonable to prioritize water treatment over water supply. It is noted that the proportion of solid waste disposal and ecological environmental protection is similar, indicating a close relationship between the two. The harmful substances contained in solid waste and its leaking liquid will change the properties and structure of soil and have a serious adverse impact on crops, plant growth and soil environmental quality. Therefore, solid waste treatment is beneficial to the development of ecological environmental protection to a large extent. Internet infrastructure construction is characterized by top-down and advanced professional technology. The development of internet infrastructure must depend on professional scientific research. The time span is large, hence its ranking at the bottom makes sense.

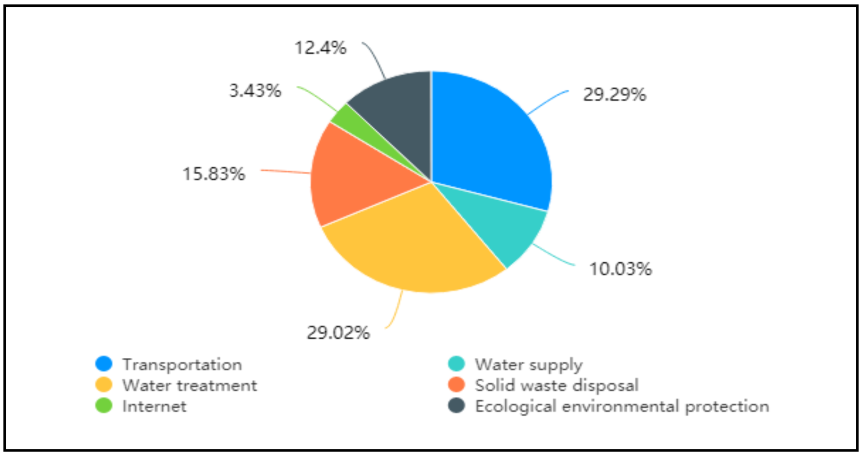


Figure 11: The priority for infrastructure construction

Table 7 shows the correlation and significance level between respondents' priority for infrastructure construction with the independent variable and the current level of urban and rural infrastructure construction with the dependent variable. Spearman's Rho correlation (*r*) and significance level (*p*) were applied to the results of this analysis.

As a result, respondents' priority for infrastructure construction and the current level of urban and rural infrastructure construction not only show 0.01 level of significance but also have a significant positive correlation. ($r > 0$ indicating that there is a significant correlation between variables; $p<0.01$ indicating that a significant correlation between variables).

Table 7: Correlation between Respondents' Priority for Infrastructure Construction and Current Level of Urban and Rural Infrastructure Construction

	Independent Variable - Respondents' Priority for Infrastructure Construction	
Dependent Variable - Current Level of Urban and Rural Infrastructure Construction	**Spearman's Rho (*r*)**	**Significant Level (*p*)**
The status of water supply	0.411	0.000
The status of wastewater treatment	0.667	0.000
The status of roads	0.522	0.000
The status of bridge	0.864	0.000
The status of E-communication, WIFI, etc.	0.815	0.000
The status of power supply	0.290	0.000
The status of disposal of solid waste (e.g. household waste)	0.753	0.000
Abandoned land	0.587	0.000

Figure 12 shows the importance of infrastructure for traveling to all respondents. As can be seen, road accounted for the most (46.97%), followed by bus stops (43.01%). Bridges ranked third (6.60%) followed finally, by railways (3.43%). The proportion of highways and subways is 0.

Road is the most widely used in all transportation infrastructure construction, and is also the premise of the rest of the transportation infrastructure construction and development. Bus station is a mass benefit in the construction of transportation infrastructure, which can obviously promote the efficiency of transportation. The bridge is the closest to the function and attribute of the road, but the function of the bridge is limited, such as height and weight limit. Due to this, some vehicles cannot enter, and because the bridge structure leads to the cost and maintenance cost is higher than the road, the importance of the bridge is far less than the road. The use of railways allowed large quantities of goods to be transported simultaneously, more efficiently than road transport.

Highways are often used for intercity transportation, not urban and rural transportation within a city. Subways are difficult to build and have the highest cost of construction and maintenance. Besides, it is only used in the economic and business centers of megacities. Therefore, subway is not suitable for most cities.

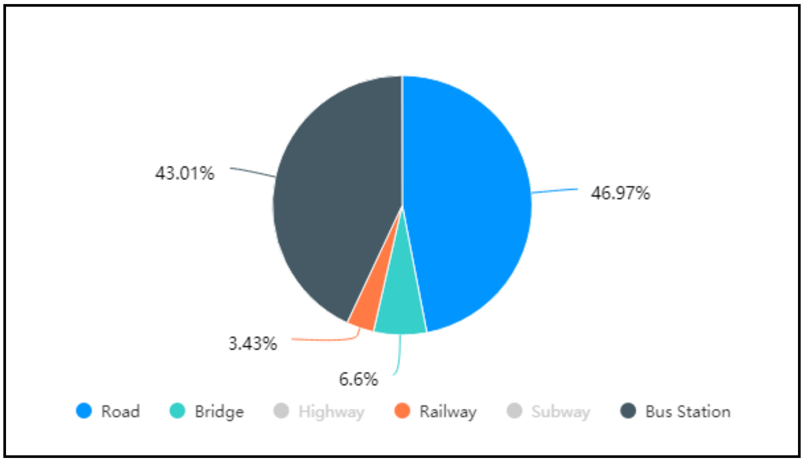


Figure 12: The important infrastructure for traveling

Based on the data derived from the priority for infrastructure construction in Table 8 and Figure 11 as well as the important infrastructure for traveling in Table 9 and Figure 12, the following inequality (1) & inequality (2) were found:

X11 (46.97%) > X12 (43.01%) > X16 (6.6%) > X14 (3.43%) (1)
X22 (29.02%) > X25 (15.83%) > X26 (12.4%) > X21 (10.03%) > X23 (3.43%) (2)

Table 8: The priority for infrastructure construction from respondents

Priority for Infrastructure Construction	**Respondents**	
	Mean	**Standard Deviation**
Transportation	1.25	0.44
X12 (Water treatment)	2.00	0.00
X25 (Solid waste disposal)	1.17	0.38
X26 (Ecological environmental protection)	1.00	0.00

Table 9: The Status of Road, Bridge and Bus Station Impact on The Important Infrastructure for Traveling

The Status of Transportation Infrastructure	**Important Infrastructure for Traveling**					
	1.0		**2.0**		**6.0**	
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**
X11 (Road)	3.83	0.38	3.64	0.50	4.10	0.82
X12 (Bridge)	2.74	0.44	3.18	0.40	3.52	0.67
X16 (Bus Station)	2.72	1.17	4.18	0.98	5.00	0.00

Discussion of Findings in Section D: Indicators for Evaluating the Contribution of Infrastructure Construction to Coordinated Urban-Rural Development

By discussing the data analyzed, we can obtain some basis for ranking the contribution indicators of infrastructure. In particular, greenery is affected by the conditions of solid waste disposal; X25 (Solid waste disposal) is ranked ahead of X26 (Greenery). The development trend of power supply infrastructure construction is slow. So, it ranks behind internet infrastructure construction. Land planning, based on the development of greenery and all infrastructure, ranked last. Therefore, the final indicators for evaluating the contribution of infrastructure construction to coordinated urban-rural development can be obtained in Table 10:

Table 10: Indicators for evaluating the contribution of infrastructure construction to coordinated urban-rural development (Made by Author)

Categories of indicators	Indicators	Code
Social benefit evaluation	Road	X 11
	Bus Station	X 16
	Bridge	X 12
	Railway	X 14
Environmental and ecological benefit evaluation	Wastewater treatment	X 22
	Solid waste disposal	X 25
	Greenery	X 26
	Water supply	X 21
	Internet technology	X 23
	Land planning	X 27
	Power supply	X 24

CONCLUSION

The proposed research model was tested through a survey of urban and rural respondents in Maonan, Maoming, Guangdong, China. The results found that the level of development of infrastructure construction in China's urban areas is much higher than that in rural areas. This is because China does not have a perfect system that focuses on the coordinated development of urban and rural infrastructure construction. Finally, based on the collected data and the previous theoretical model, this study puts forward indicators for evaluating the contribution of infrastructure construction to Urban-Rural coordinated development, as a promotion strategy for coordinated development of urban and rural infrastructure construction. Therefore, future research can focus on the influence of coordinated development of urban and rural infrastructure construction on land planning, because infrastructure construction has the greatest demand for land. In addition, it is also possible to further study on forming a system for coordinated development of urban and rural infrastructure construction.

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